

# The NASA Ames Life Sciences Data Archive: Biobanking for the Final Frontier

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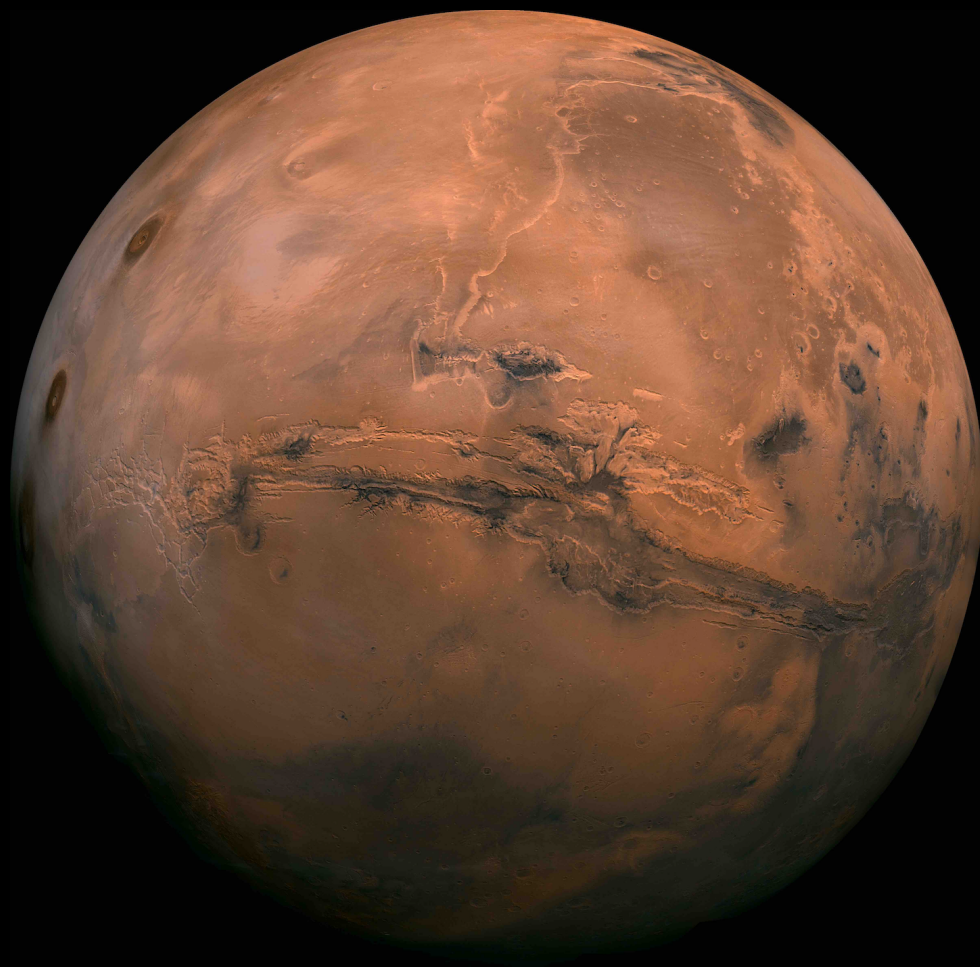
# Outline



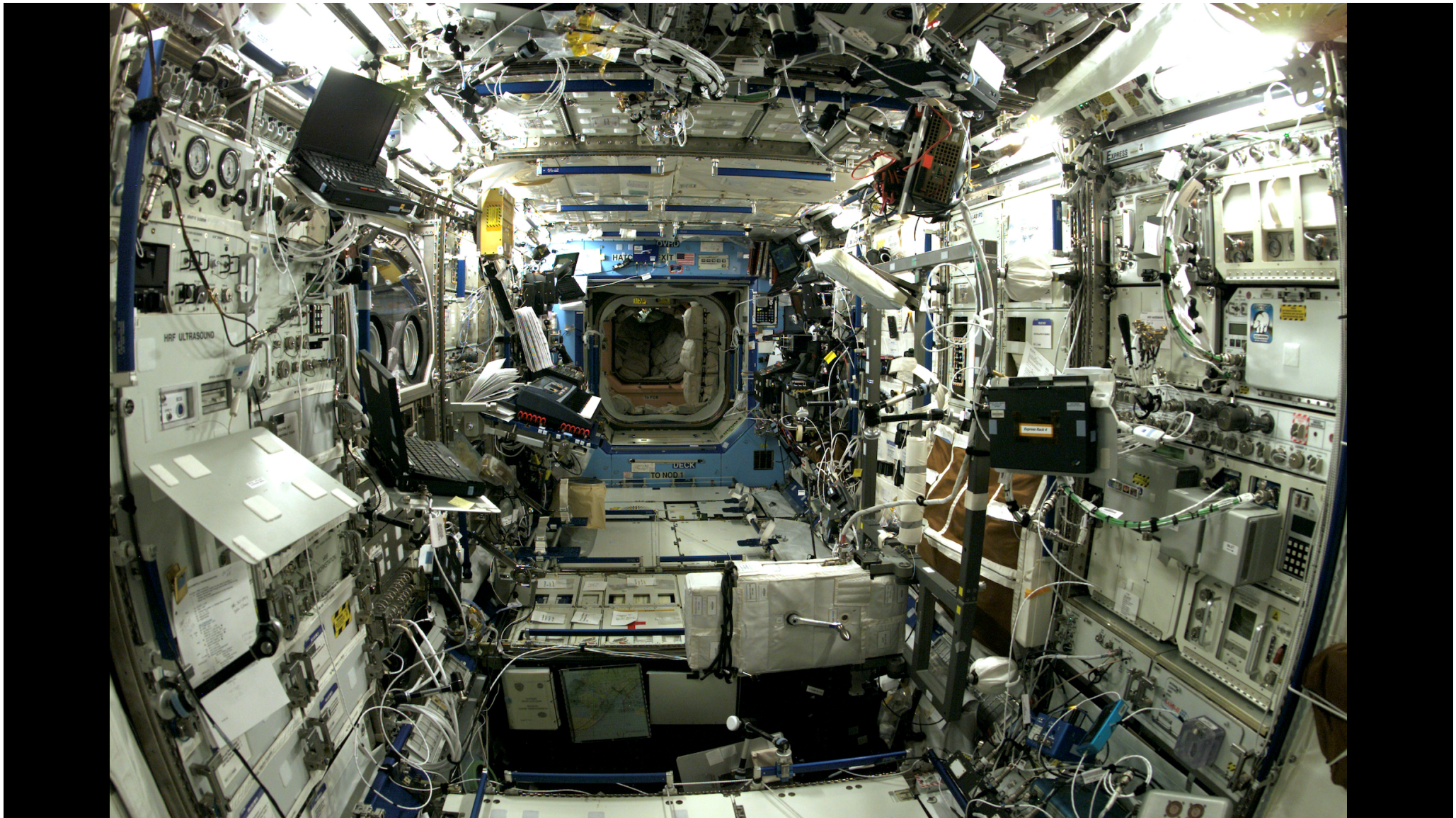
- **Background**
  - NASA Institutional Scientific Collection
  - NASA Ames Biobank
- **Objectives of the NASA Ames Biobank**
- **Science product flow of biospecimens and data**
- **Approach**
  - NASA Ames projects performing sample testing
- **Summary / Lessons Learned**
- **Future work**











# Background: The NASA Institutional Scientific Collection

Policy to provide curation of NASA's Institutional Scientific Collections (ISC) as a set of physical specimens, living or inanimate, created for the purpose of supporting science and serving as a long-term research asset, and, as appropriate and feasible, the associated specimen data and materials.

- **Extraterrestrial materials**
- **Space-exposed hardware deemed critical for curation for research by the appropriate authority,**
- **Biological and human research samples**
- **Physical materials derived from space-flight programs**





## Background: The NASA Life Science Data Archive



- **NASA's Life Sciences Data Archive (LSDA) is an active archive that provides information and data from 1961 (Mercury Project) through current flight and flight analog studies (International Space Station) involving human, plant and animal subjects.**
- **Much of the information and data are publicly available online. Some data are potentially attributable to individual human subjects, and thus restricted by the Privacy Act, but can be requested for research.**

<https://lsda.jsc.nasa.gov/>





# Background: The NASA Ames ISC



## Ames Life Science Data Archive (ALSDA)

- **NASA Ames Research Center project node of the NASA Space Life Sciences Data Archive**
- **Responsible for the capture, preservation and dissemination of life science data and biospecimens from NASA Ames-managed flight and ground experiments**
- **The ALSDA manages the ISC specimens stored in the Biospecimen Storage Facility**



<https://www.nasa.gov/ames/research/space-biosciences/alsda>



# Background: NASA Ames Biobank



## The Biospecimen Storage Facility (BSF)

- The BSF maintains fixed and frozen biospecimens from Space Shuttle and International Space Station missions (1985 to current).
- Services include specimen receipt into the repository, data base, storage and distribution.
- Approved for storage of tissues with radioactive isotopes
- Six -80°C Freezers, ~0.6 m<sup>3</sup> each including a back-up)
- Fail-safe power backup; connected to emergency generator; all units alarmed and monitored 24/7
- Inventory management with secure database
- species, tissue type, fixation, treatment, location, other metadata, and chain-of-custody information





# Objectives of the Ames Biobank

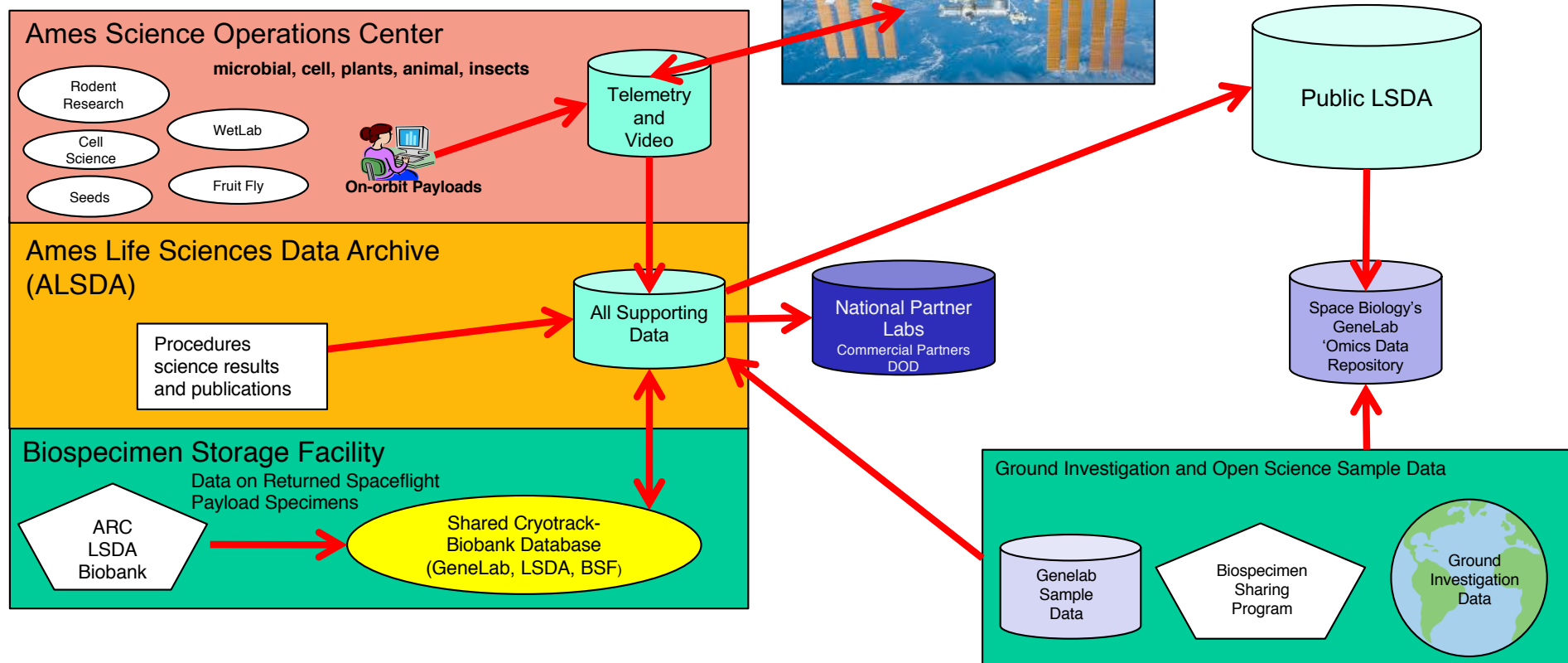
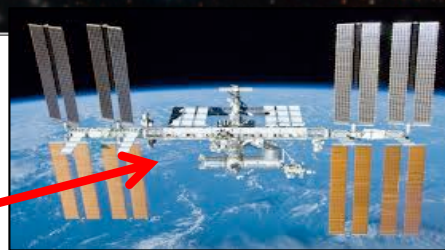


- **Guide development of the NASA Procedural Requirements (NPR) for Curation of Institutional Scientific Collections**
- **Support NASA open science initiatives**
- **Make ISC samples publically known to science community**
- **Further develop and refine our best practices for biobanking**





# Science Product Flow of Biospecimens and Data





# Approach



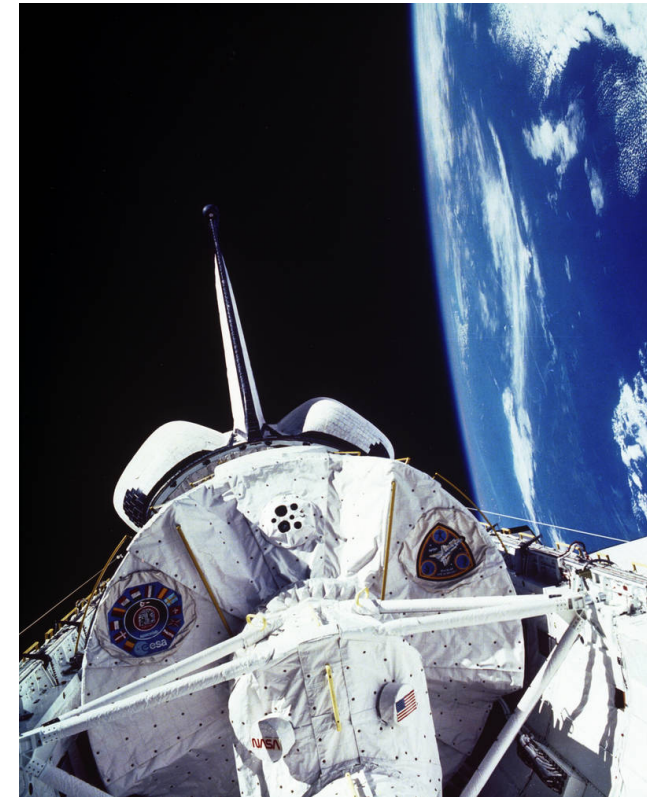
- **Establishment of Non-Human ARC Biobank Process Management Board and Charter**
- **Implementation of procedural requirements meeting biobank standards**
  - Viability Test Plan for Institutional Scientific Collection
    - decision tree, trade study
- **Projects performing sample testing at Ames**
  - Biospecimen Sharing Program and GeneLab



# Examples of Biospecimens in ARC Biobank



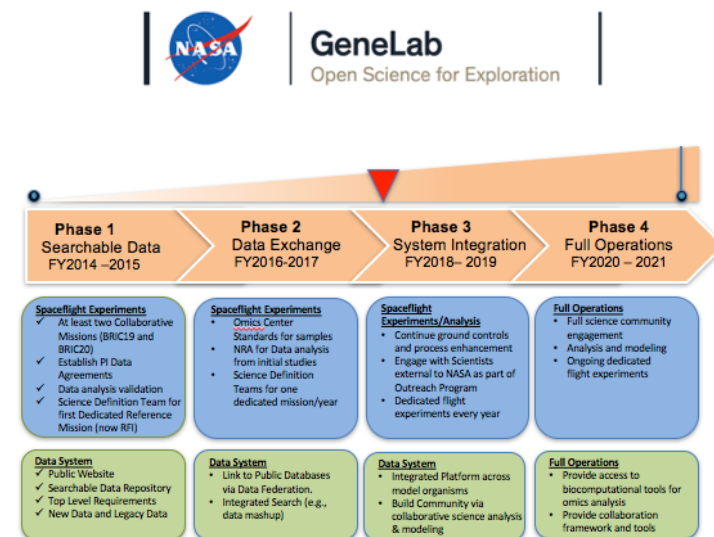
AVAILABLE BIOSPECIMENS	2016	2014	2011	2010	2007	2001	1996	1995	1993	1993	1991	1985
Tissue	RR3	RR1	CBTM3	Immune	CBTM2	CBTM	NIH.R3	NIH.R2	PARE.03	SLS-2	SLS-1	SL-3
	Mouse	Mouse	Mouse	Mouse	Mouse	Mouse/Quail	Rat	Rat	Rat	Rat	Rat	Rat
Blood, Bone marrow, Heart, Lymph nodes, Spleen	X				X		X		X	X	X	
Caecum, Colon, Duodenum, Gastrointestinal Tract, Gut, Ileum, Intestine, Jejunum, Pancreas, Proventriculus, Stomach	X	X	X		X	X	X		X	X	X	
Adrenal glands, Liver, Salivary glands, Thymus, Thyroid	X	X	X	X	X		X	X	X	X	X	
Bladder, Fecal samples, Kidney	X	X	X	X	X		X		X	X	X	
Adipose, Skin	X	X			X	X	X		X			
Adductor longus, Diaphragm, Extensor digitorum longus, Gastrocnemius, Patellar tendon, Plantaris, Soleus							X		X	X	X	X
Brain, Eyes, Hypothalamus, Pituitary	X				X		X		X	X		X
Gonads, Ovaries/uterus, Testis	X				X		X		X	X	X	
Lung, Trachea	X			X	X		X		X	X	X	
Femur, Humerus, Jawbone, Parietal bone, Ribs, Sternum, Tail, Tibia, Vertebrae	X	X			X	X	X			X		



# NASA Ames Projects Performing Sample Testing

## NASA GeneLab

- **NASA GeneLab provides spaceflight and spaceflight related multi-omics data**
- **From International Space Station to deep space**
  - Maximizing multi-omics dataset analysis and generating higher-order data from every spaceflight with biology payloads
- **Supporting ground studies**
- **100+ Datasets on line**
  - More on the way
- **Openly available now (to anyone, anywhere)**



<https://genelab.nasa.gov/>



# NASA GeneLab: Data Set Focus



- Genomics
- Transcriptomics
- Proteomics
- Metabolomics

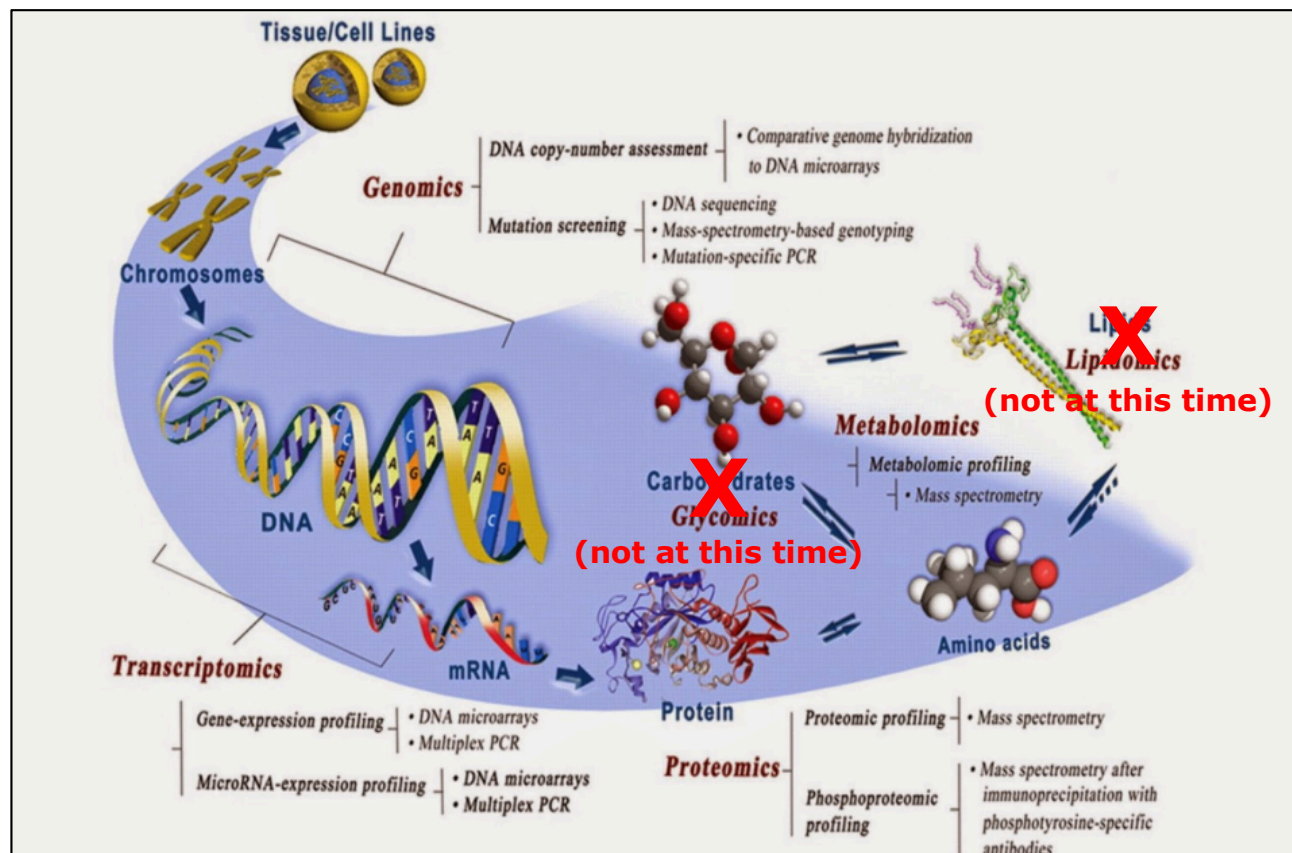


Image source: Wu RD et al. JDR 2011; 90:561-572

[http://www.iss.it/binary/cnmr4/cont/Calissano\\_Omics\\_and\\_links\\_with\\_biobanks\\_and\\_registries\\_sept.\\_16\\_2014\\_.pdf](http://www.iss.it/binary/cnmr4/cont/Calissano_Omics_and_links_with_biobanks_and_registries_sept._16_2014_.pdf)

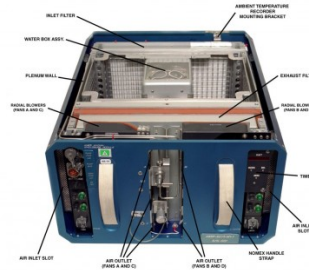


# NASA Ames Projects Performing Sample Testing



## Biospecimen Sharing Program (BSP)

- Research on the ISS is an important tool for understanding effects of space flight.
- Spaceflight experimentation poses various challenges:
  - Limited number of samples
  - Limited number of flights
  - Limited capability to process tissues on orbit
- PIs have tissues of interests to meet their scientific aims but not all tissues are needed for their research.
- Developed over 50 years ago by NASA Ames to maximize science return

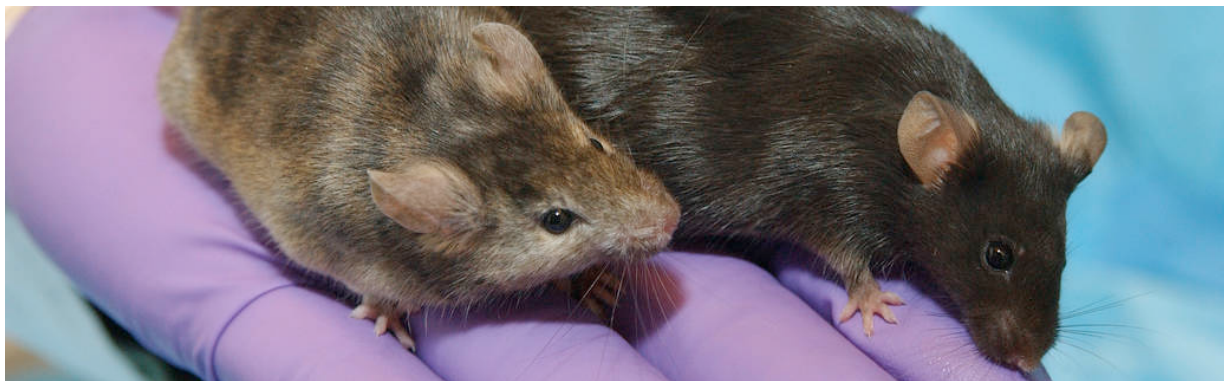




# Biospecimen Sharing Program



- **Upon completion of a flight or ground investigation, tissues are collected per a tissue sharing agreement between the primary investigator(s) and NASA**
- **Dissection flow is executed by the primary investigator(s) and the NASA Rodent Research Biospecimen Sharing Program (BSP) team to collect remaining tissues**
- **BSP tissues are delivered to the NASA Ames biospecimen storage facility (BSF)**
  - Biospecimen requests can be made as part of the NASA-solicited proposal process or as an unsolicited proposal via the ALSDA website “Data Request” form.





# Tissue Quality Test for the Rodent Research 1 Mission Samples (RR1)



- **Objective: To assess if the tissues collected from Post-Flight BSP dissection are of high quality for analysis of gene expression**
  - The RR1 carcasses were stored at  $-80^{\circ}\text{C}$  for over 3 months on ISS and for ~2 months at Ames upon return to Earth (total  $> 5$  months at  $-80^{\circ}\text{C}$ )
- **Methods:**
  - Tissues were collected from frozen carcasses that were subjected to freezing and thawing
  - RIN (RNA integrity number) values of select tissues, including liver, spleen, kidney, brain, diaphragm, eyes, thymus, adrenals, were determined as a measure of tissue quality



RESEARCH ARTICLE

## Preservation of Multiple Mammalian Tissues to Maximize Science Return from Ground Based and Spaceflight Experiments

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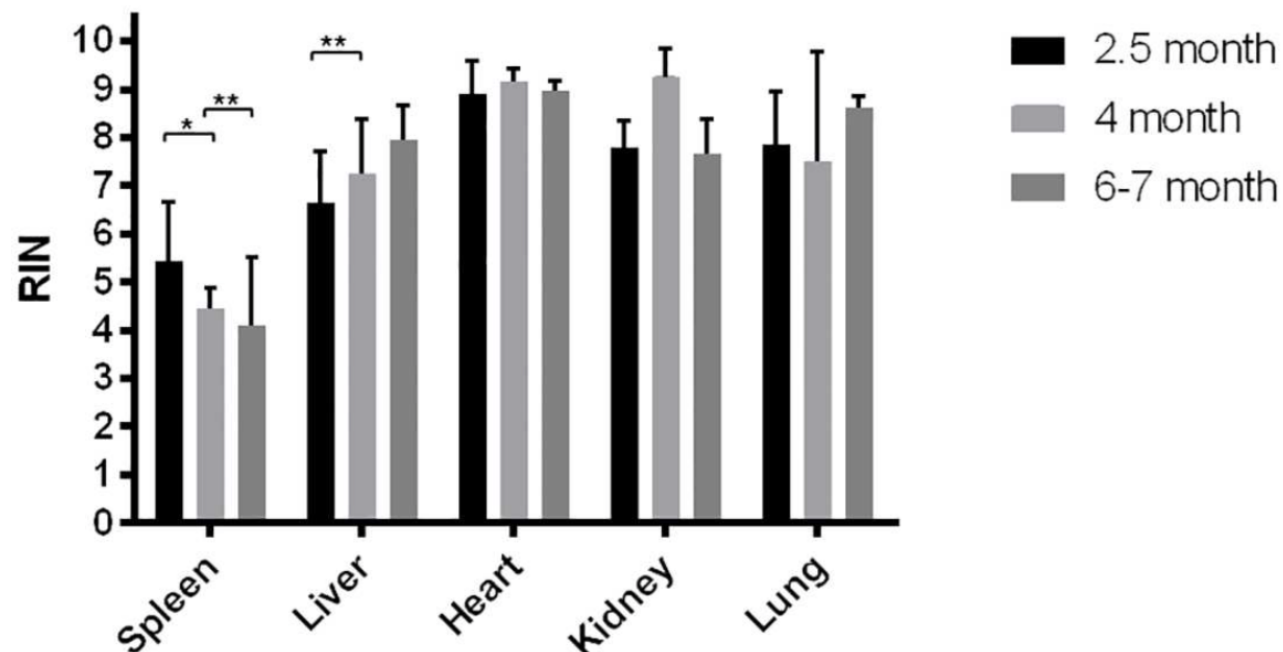
# Summary of RIN Values



Sample	RIN	Storage at -80°C (months)	Collection Time
Spleen preserved in RNAlater	> 8	1	≤100 minutes
	≥ 8.5	3.5	≤25 minutes
	≥ 8.5	11	≤5 minutes
Liver frozen on dry ice	≥ 7	1	≤85 minutes
	≥ 8.5	4.5	≤25 minutes
	≥ 8.5	11	≤5 minutes
Sample	RIN	Storage at -80°C (months)	Collection Time After Removal from -80°C Freezer
WC: spleen dissected after carcass storage at -80°C	> 5	2.5	≤5 minutes
	> 5	4	≤5 minutes
	> 4	6 to 7	≤5 minutes
WC: liver dissected after carcass storage at -80°C	> 6.5	2.5	≤5 minutes
	> 8	4	≤5 minutes
	> 7.5	6 to 7	≤5 minutes



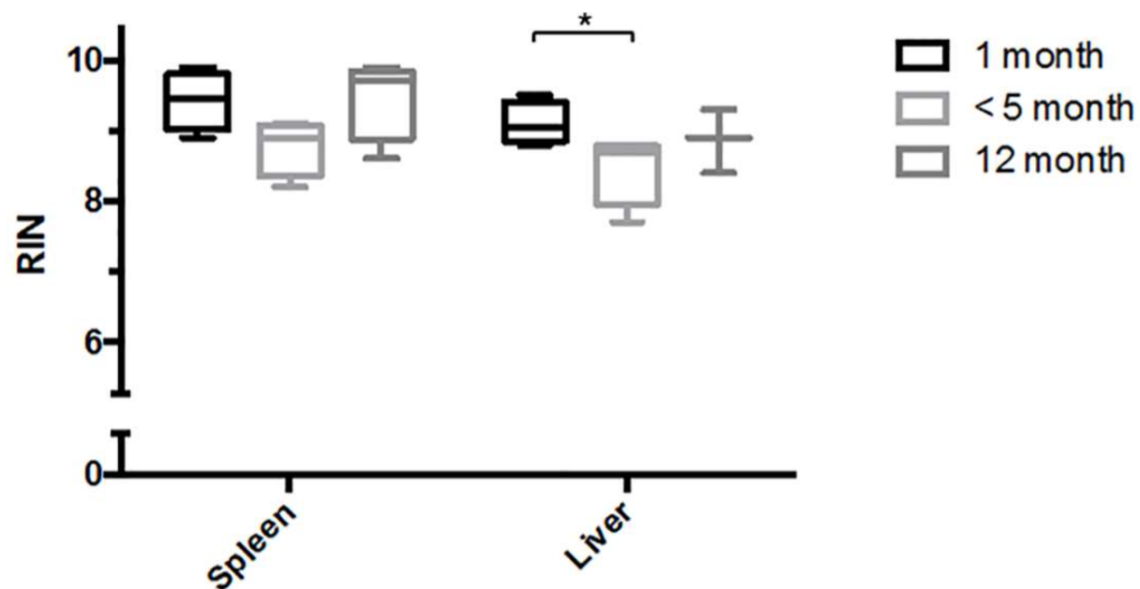
# RIN of samples from Whole Frozen Carcasses



Whole frozen carcasses (WC) were frozen using an aluminum block that was pre-chilled with liquid nitrogen to simulate the freezing kit used on- orbit (2.5, 4 and 6–7 month WC) prior to being placed into a -80°C freezer. Spleen, liver, heart, kidney, and lung were collected within 30 minutes post thawing of the WC, and preserved in RNAlater prior to analysis. Data sets were assessed for normality using the Shapiro-Wilk test, followed by the one-way ANOVA and Tukey's post hoc test. Values are means  $\pm$  SD (n = 9 for 2.5 month, except n = 8 for lung; n = 4, 5, 6, 3, 4 for 4 month spleen, liver, heart, kidney and lung, respectively; n = 3 for 6–7 month). \*  $p < 0.05$ ; \*\*  $p < 0.01$



# Effects of long duration storage at -80° C on RNA quality



Spleens and livers were collected up to 5 minutes post-euthanasia. Spleens were preserved in RNAlater, and livers were frozen on dry ice. Samples were stored at -80° C for 1, 3.5, and 11 months for spleen, and 1, 4.5, and 11 months for liver. Samples stored up to 11 months at -80° C resulted in RIN values greater than 8. Data sets were assessed for normality using the Shapiro-Wilk test, followed by the Kruskal-Wallis test. Values shown are medians within interquartile (boxes) and full range (whiskers) (n = 4 for all months except for n = 3 for Liver 12 months). \* p<0.05



# Summary



- **Refined Ames Biobank best practices**
- **Established Science Review Board to review disposition recommendations for biobank biospecimens**
  - Completed review of viability testing methods
- **ARC Biobank will rely on proposals from scientific community to perform functional analysis and provide results and publications to NASA**
- **Developed an RNA-Integrity viability testing methodology, project documentation, and supporting operating procedures**



## Summary (2)



- **Select tissues from the Space Station can be utilized for gene expression and histology studies despite being retrieved from carcasses subjected to at least two freezing and thawing cycles**
  - BSP PIs have noted that samples are high quality
- **These results expand potential science return from valuable and limited rodent experiments in space**
- **Created scientific investigation opportunities, including temporal assessment of tissue viability**



# Future Work




**NASA Request for Information on ARC Biobank Samples**

**NASA Solicitation and Proposal Integrated Review and Evaluation System  
(NSPIRES) <https://nspires.nasaprs.com/external/>**



# NASA Ames Biobank

<https://www.nasa.gov/ames/research/space-biosciences/biobank>

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### ARC Biobank | Non-Human Biospecimens

Spaceflight biospecimens from NASA's [Space Life Sciences](#) [Space Biology](#) and [Human Research](#) programs provide a unique and rich foundation for conducting research that leads to a better understanding of how the spaceflight environment affects biological systems and processes. From this understanding, new technologies could be developed to mitigate health risks associated with space travel. These technologies will ultimately benefit human health on Earth through advancements in medical and pharmaceutical applications.

Biospecimens are collected from [space flight experiments](#) conducted aboard the Space Shuttle and International Space Station. These specimens are made available as part of the Institutional Scientific Collection (ISC) Biospecimen Sharing Program (BSP). The ARC Biobank, a NASA ISC, is the only public source of space-flown non-human specimens. The most recent addition to the ISC includes tissues from [Rodent Research](#) experiments on ISS.

These specimens have value for space, medical, and pharmacological research. The National Research Council states, "Studies with rodents in space have been useful and important for extrapolating the implications for humans living in space and more work remains to be done" (2011). For a list of publications resulting from BSP research, click [here](#).

Search for Biospecimens





# For More Information



**NASA Life Science Data Archive (LSDA) / Biospecimen Requests:**

<http://lsda.jsc.nasa.gov>

**NASA Ames Life Science Data Archive (ALSDA):**

<https://www.nasa.gov/ames/research/space-biosciences/alsda>

**NASA Ames Space Biosciences**

<https://www.nasa.gov/ames/research/space-biosciences>

**NASA GeneLab**

<https://genelab.nasa.gov>

**NASA Ames Institutional Scientific Collection: Contact Helen Stewart:**

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